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EOS MLS Observations of Ozone Loss in the 2004–2005 Arctic Winter

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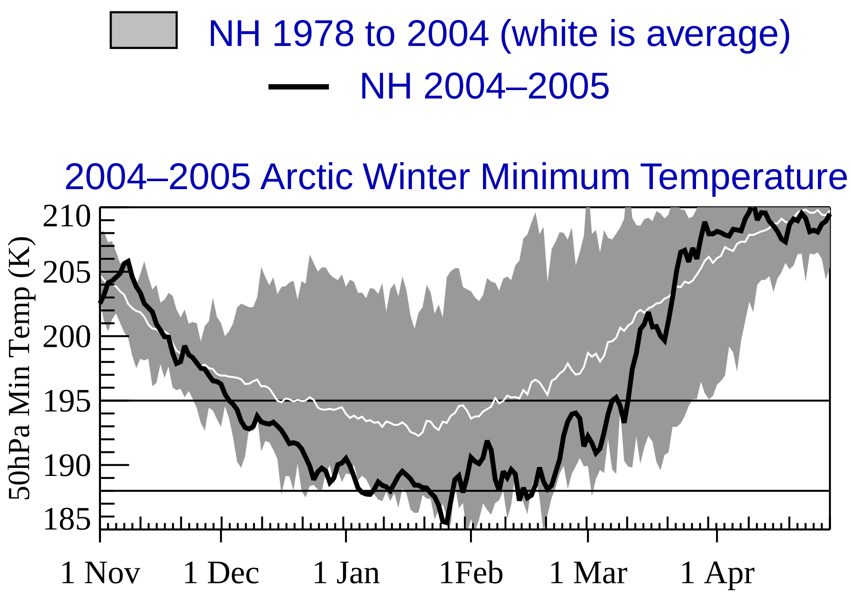
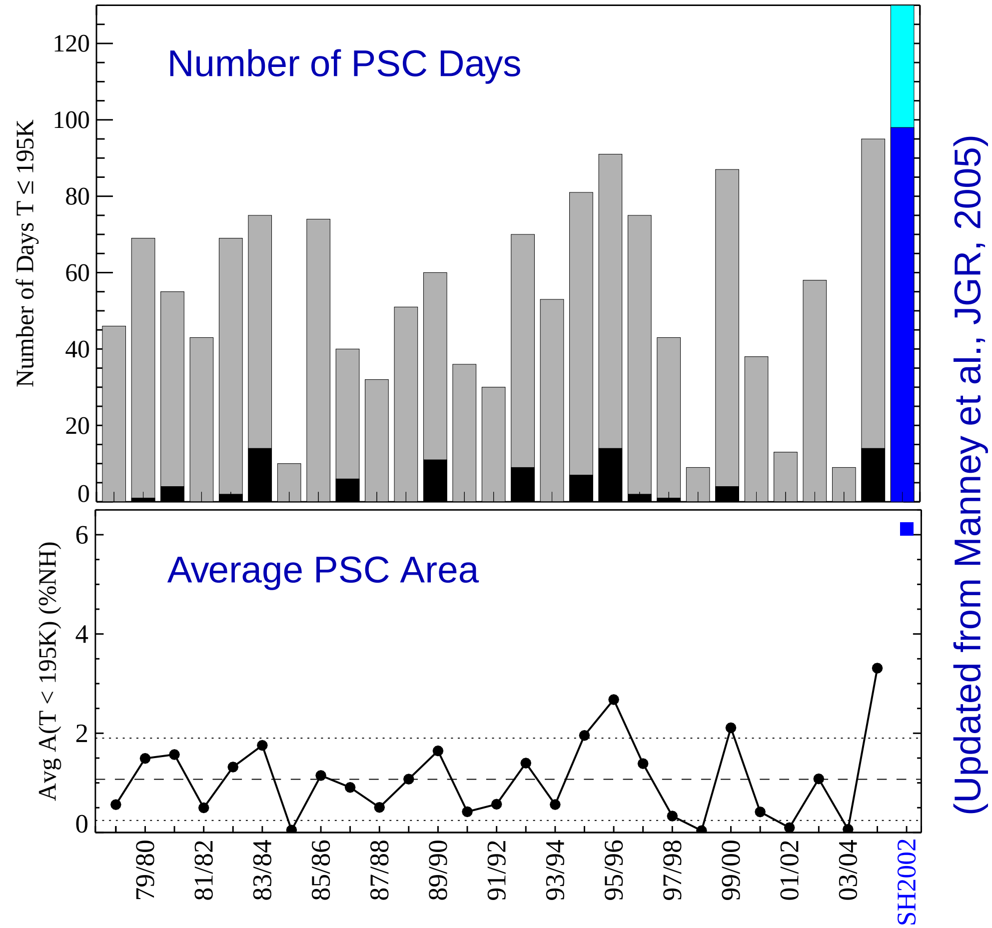
Material herein from Manney et al., GRL, submitted, preprint on http://mls.jpl.nasa.gov

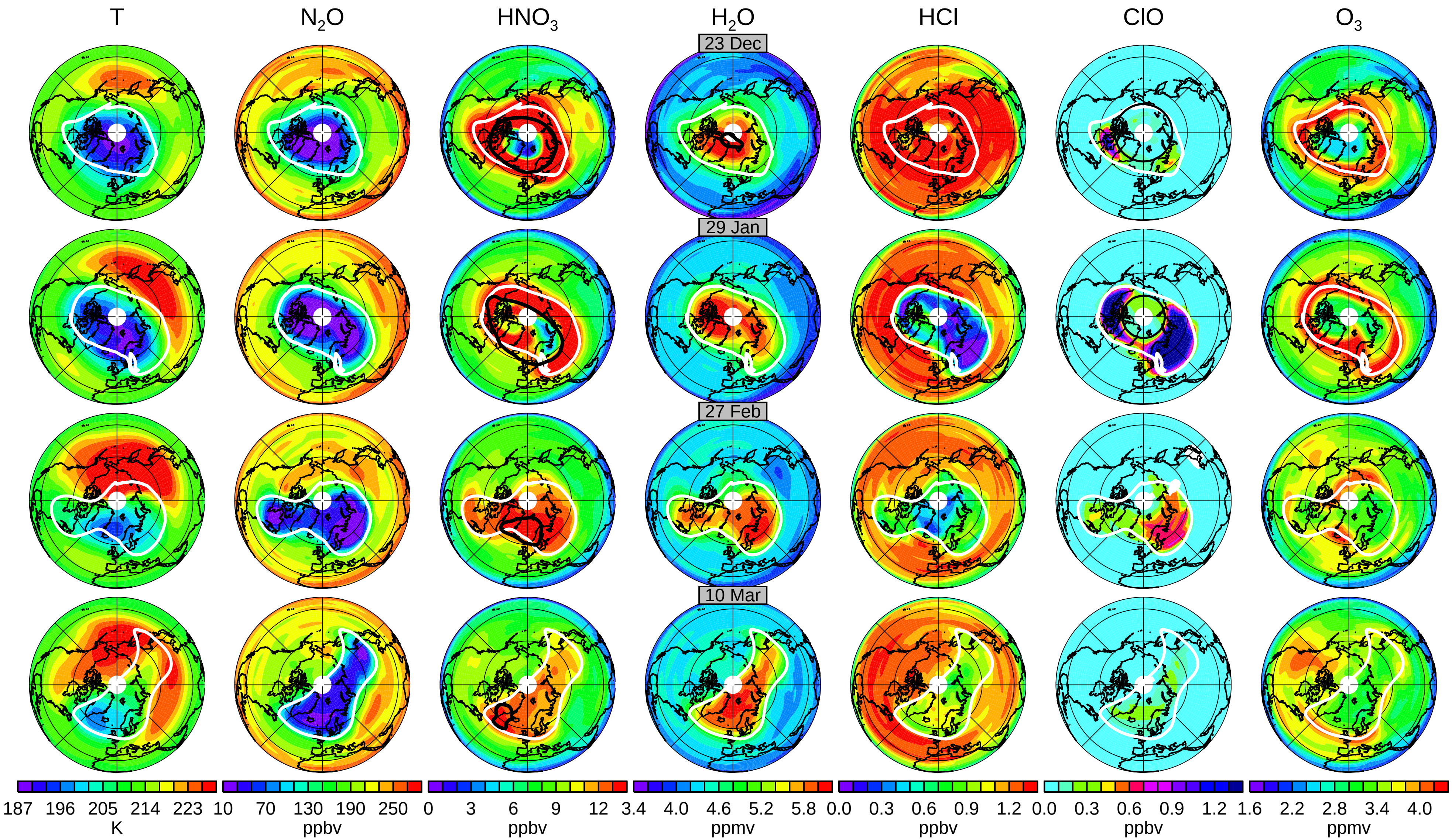
The 2004–2005 Arctic Winter: Meteorological Conditions





- The 2004–2005 Arctic winter was the coldest on record, with more days and a larger region where PSCs could form than any previously observed Arctic winter
- It was still not even close to conditions during the warmest Antarctic winter (2002), however
- Lowest temperatures occurred in late January, concurrent with an upper tropospheric ridge that led to intrusions into the lower stratospheric vortex
- Low temperatures and PSC formation were halted by a major final warming beginning in early March

EOS MLS Observations of Arctic Ozone Loss in 2005 at 520 K (~20 km)



- ❑ Significant chlorine activation started in the sunlit portion of the vortex in late December
- ❑ Even before the onset of chemical loss, O_3 was lower in the vortex core than near the edge
- ❑ N_2O, H_2O, and O_3 show evidence of intrusions (e.g., 29 January) throughout the winter

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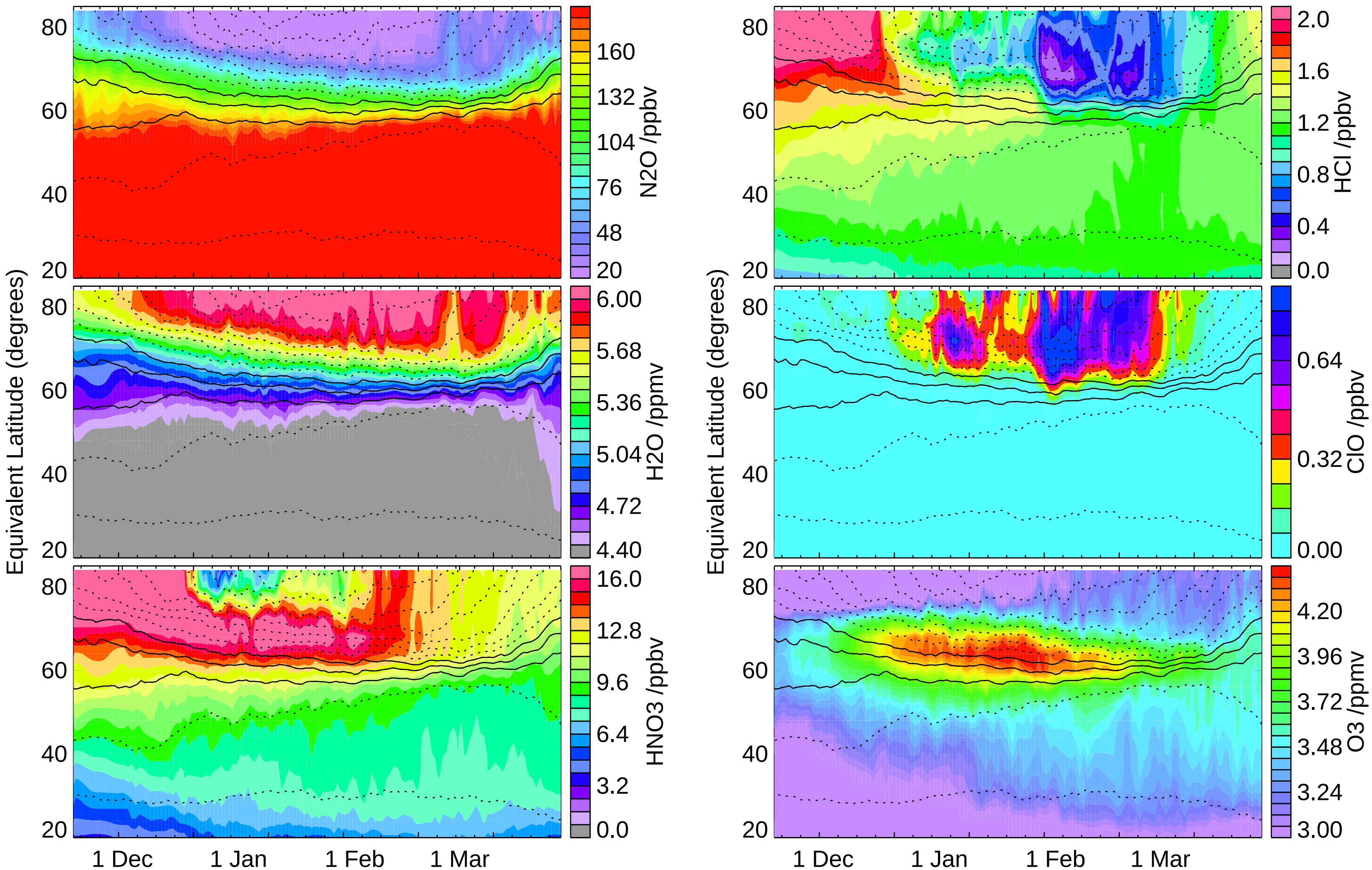

- Vortex N_2O began to increase in February, indicating that descent no longer dominated
- HNO_3 indicates extensive PSC activity in late December through mid-February
- Chlorine became activated by late December and was deactivated by ~10 March
- Ozone started to decrease in late January, but both chemical loss and mixing can reduce vortex edge values

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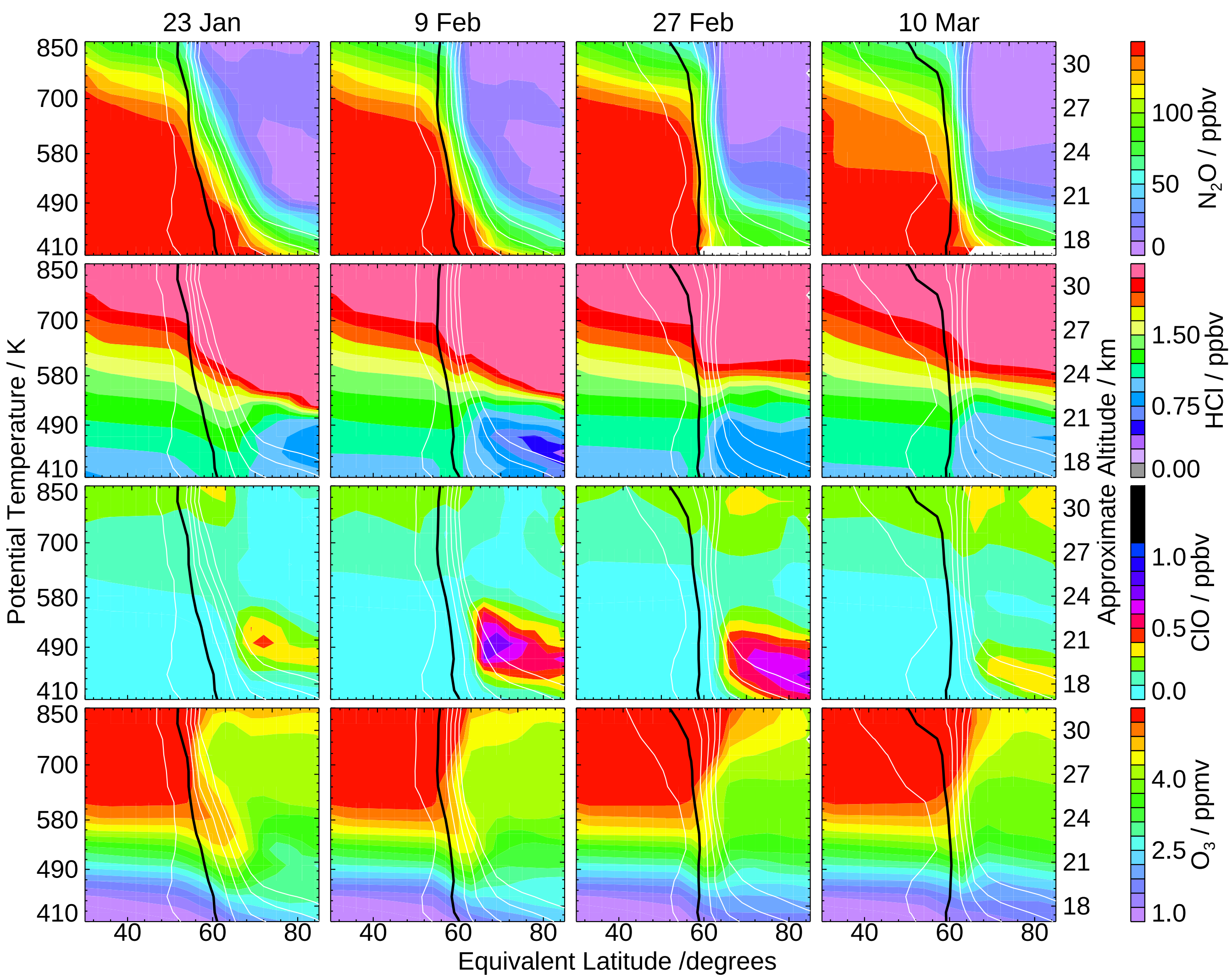
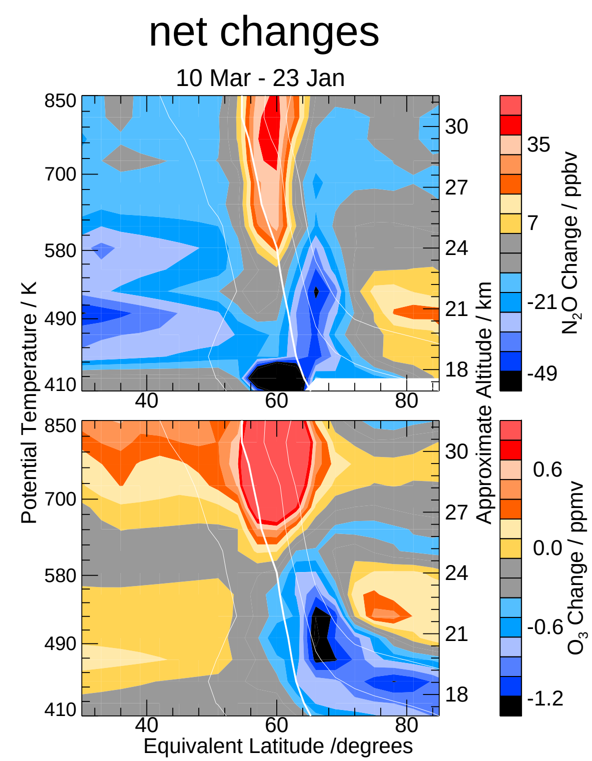
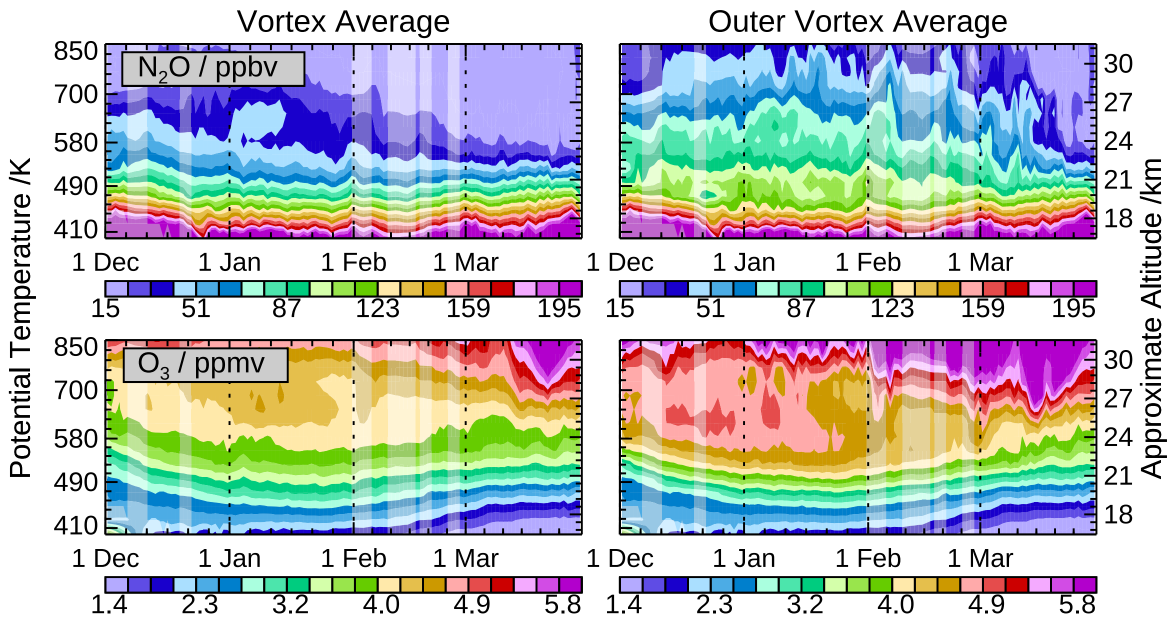


- N$_2$O decreased in the outer vortex region below ∼600 K (∼25 km), indicating that descent was the dominant process there
- In contrast, a net increase in N$_2$O in the vortex core indicates mixing with air from near the vortex edge



- Mixing would increase ozone in the vortex core below ∼500 K
- Thus ozone decreases in these regions indicate chemical loss, and some of that loss is masked by transport processes
- Maximum **observed** O$_3$ decrease is ∼1.2 ppmv in the outer vortex near 500 K; chemical loss is expected to be greater

EOS MLS Observations of Arctic Ozone Loss in 2005

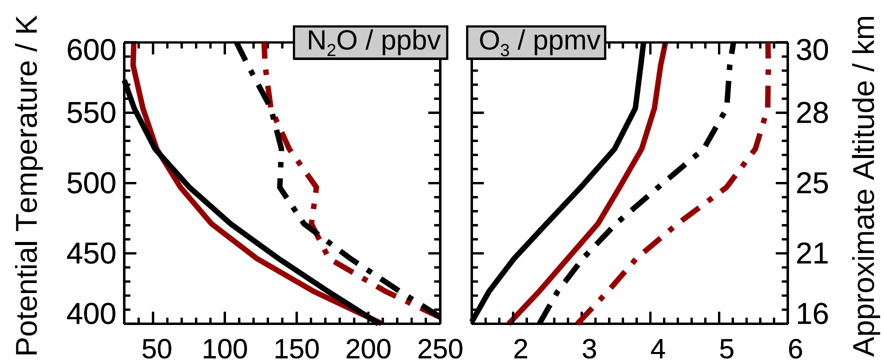


- Averages of N_2O over the vortex and outer vortex (the region with maximum decrease shown on previous slide) show the signature of descent until late January, when mixing becomes more important
- O_3 decreases are slightly larger in the outer vortex than in the vortex average, especially above ∼20 km

- Descent in these regions is estimated through the changes in N_2O and applied to the initial O_3 profile
- This yields a rough estimate of maximum **chemical** O_3 loss of ∼1.5 ppmv in the vortex average and ∼2 ppmv in the outer vortex average, both between 450 and 500 K
- However, descent is **not** the dominant process everywhere, so these chemical loss estimates are highly uncertain
- Also, localized decreases could be larger

solid = vortex average   23 January

dot-dash = outer vortex average   10 March



outer vortex curve offset by
+50 ppbv for N_2O and +1 ppmv for O_3

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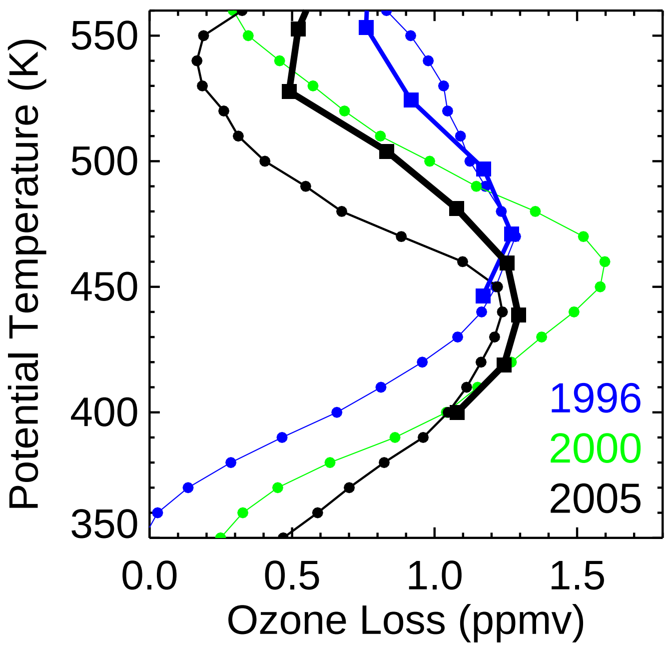

- ❑ POAM = thin lines with dots; MLS = thick lines with squares
- ❑ Vortex-averaged descent is estimated using 3D vortex-filling trajectories and a radiation code
- ❑ Chemical loss is estimated from the difference between an initial profile descended with these rates and a final observed profile for 1996, 2000 (POAM only), and 2005
- ❑ Chemical O_3 loss was comparable to that in 1996 (but with largest loss at lower altitudes in 2005) and significantly less than that in 2000

Summary

Although unusually cold, the 2004–2005 Arctic winter was also dynamically active, and temperatures rose above PSC thresholds in early March. EOS MLS observations indicate that:

- ❑ Ozone morphology in early winter, before the onset of chemical loss, and the importance of mixing processes throughout the winter, made disentangling chemical and transport effects even more difficult than usual
- ❑ Rough estimates suggest maximum chemical loss of 1.2–1.5 ppmv in the vortex average, and $\sim$2 ppmv in the outer vortex region, both near 450–500 K
- ❑ More precise estimates will require extensive analysis and modelling efforts

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